Shipping Traffic Analysis and Cost Assessment for Ballast Water Exchange En Route to the United States—an analysis revisited

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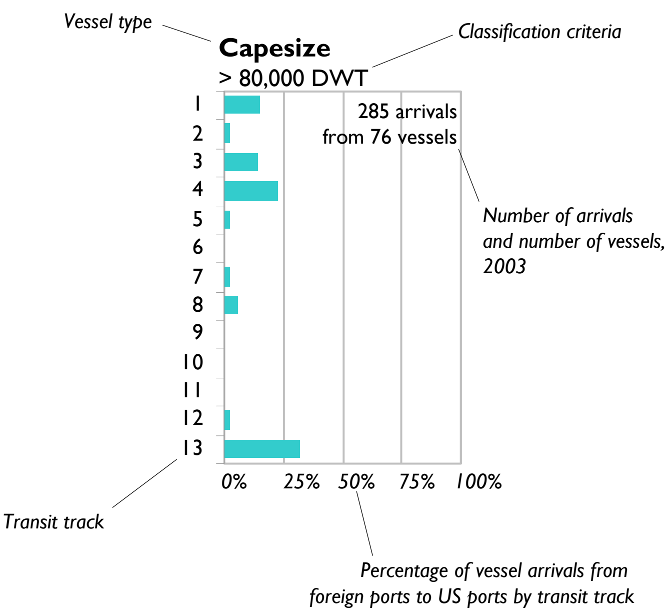
In July 2004, the Coast Guard published regulations that address ballast water management. In support of that regulation, we were required to assess the costs of ballast water exchange for vessels traveling to the US from outside the US EEZ. We have since updated that analysis using the most recent data available and a more refined categorization of ship types. The results are presented here. For the complete Regulatory Evaluation visit http://dms.dot.gov, proceed to Simple Search, and enter 14273. For more information regarding the Coast Guard's regulatory initiatives to mitigate the threat of invasive species, visit http://wwwstage.uscg.mil/hq/g-m/mso/estandards.htm

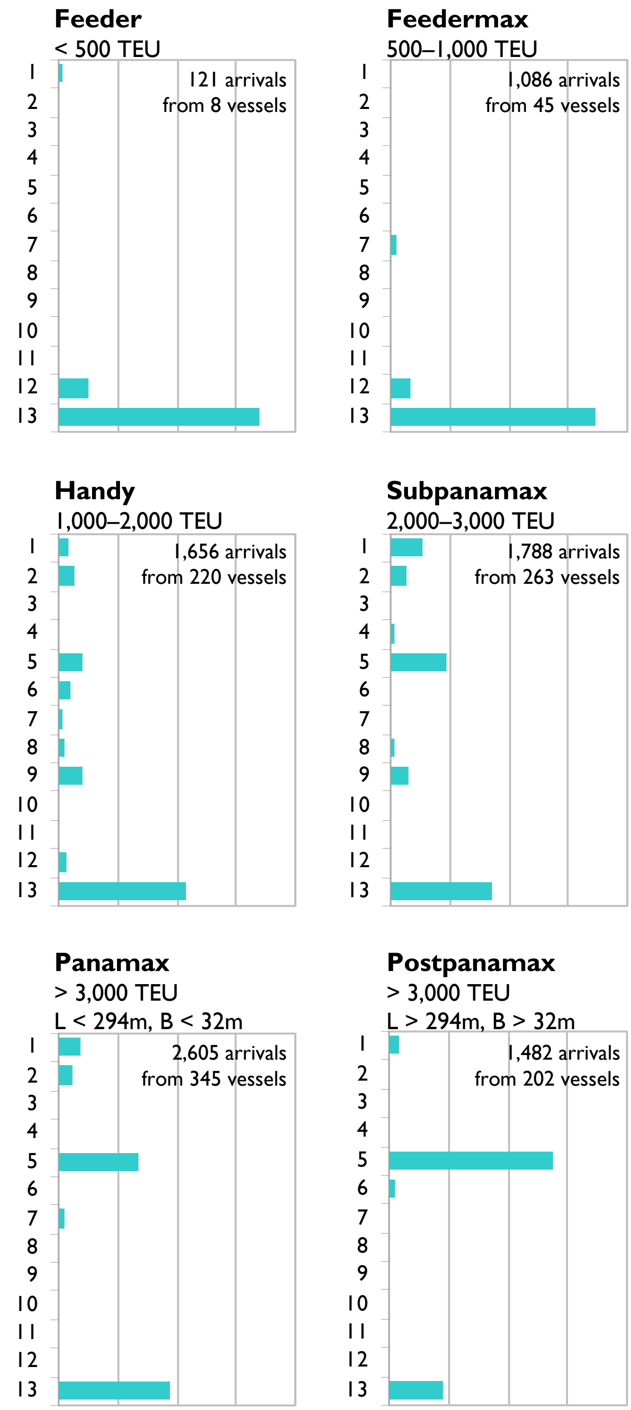
Key



Transit tracks

1 Northern Europe to the East Coast
2 Mediterranean to the East Coast
3 Northern Europe to the Caribbean and Gulf of Mexico
4 Mediterranean to the Caribbean and Gulf of Mexico
5 East Asia to the West Coast
6 Southeast Asia to the West Coast
7 South America to the East Coast
8 West Africa to the East Coast, Caribbean, Gulf of Mexico
9 Central America to the Pacific Islands
10 East Asia to Alaska
11 West Africa to the West Coast and Hawaii
12 Southeast and East Asia to the Pacific Islands
13 Transit within 200 miles of any shore

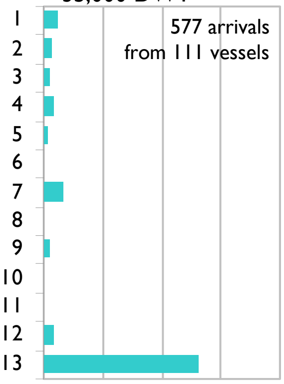
Container ships



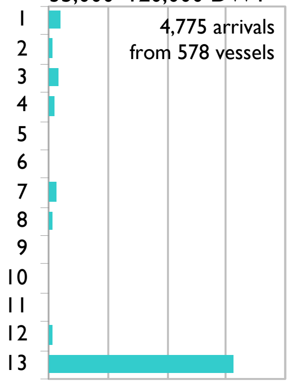
Container ships carry cargo on all transits, with ballast water in sufficient quantity to optimize the stability and efficiency of the vessel. For the smallest container ships, Feeder, we see that most of the 121 arrivals by 8 vessels were from foreign ports with transits that lie within 200 miles of shore (Track 13). All of the small- and medium-sized container ships (up to 3,000 TEU) transit primarily within 200 miles of shore, though fewer transits in this track are shown as vessel size increases. By contrast, the largest container ships, Postpanamax, which have dimensions that preclude transit through the Panama Canal, have arrivals concentrated from East Asia to the West Coast (Track 5).

Tank ships

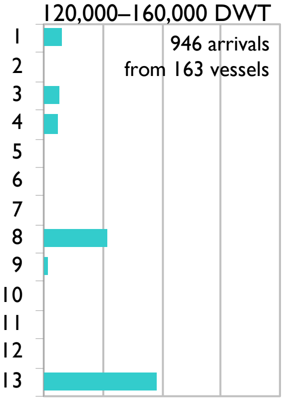
Handy
< 35,000 DWT



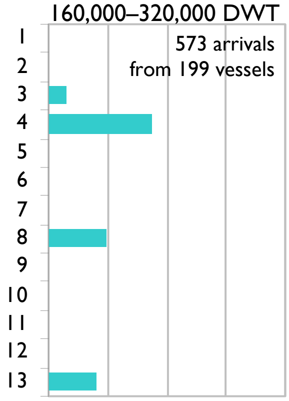
Handymax
35,000–120,000 DWT



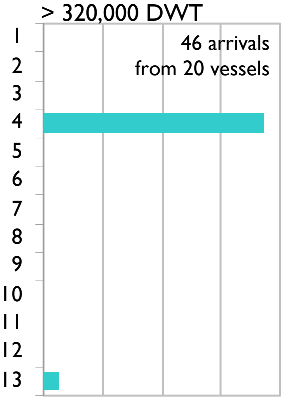
Panamax
120,000–160,000 DWT



VLCC
160,000–320,000 DWT



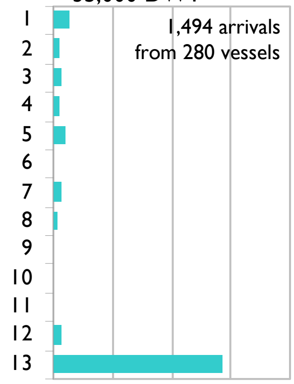
ULCC
> 320,000 DWT



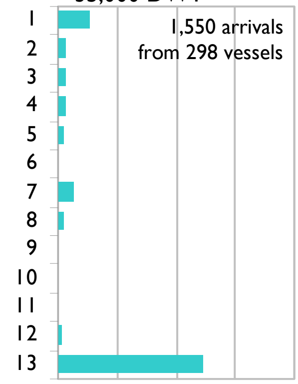
Tank ships move cargo in shipload lots and carry ballast water in the absence of cargo, rather than in addition to cargo to optimize vessel stability and performance. When looking at the relationship between the size of the vessel and the transit tracks frequented, tank ships show a similar distribution trend as container ships. The smallest vessels, those less than 120,000 DWT, Handy and Handymax, arrive predominantly from foreign ports with transits that lie within 200 miles of any shore, primarily from South America and the Caribbean and arriving at Gulf Coast ports. These tankers carry mostly petroleum product, though smaller tankers also carry wine, molasses, edible oils, concentrates, and other liquids. Petroleum from Venezuela is seen in the concentration of Handy arrivals in Track 7. West African oil is seen in the concentration of Panamax and VLCC arrivals in Track 8. As size increases to 160,000 DWT, and as cargo changes from product to crude oil, the distribution of arrivals across transit tracks changes. We see a shift from transits that lie within 200 miles of shore to transits from the Middle East through the Mediterranean (Track 4). As shown in VLCC, almost 50 percent of the arrivals are from the Mediterranean to the Caribbean and Gulf of Mexico (Track 4), while nearly all ULCC arrivals are in this track.

Chemical carriers

Handy
< 35,000 DWT



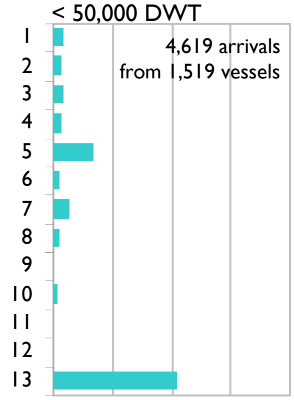
Handymax
> 35,000 DWT



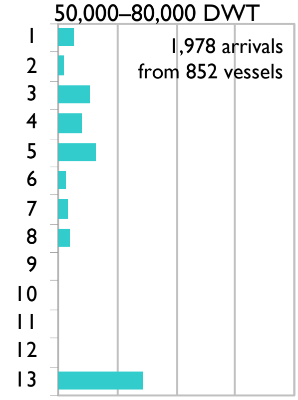
Chemical carriers transport cargo in shipload lots and carry ballast water in the absence of cargo. While transits from within 200 miles of any shore dominate chemical carrier arrivals, there are notable numbers of transits from Northern Europe to chemical facilities on the East Coast (Track 1) and from South America to the East Coast (Track 7).

Bulk carriers

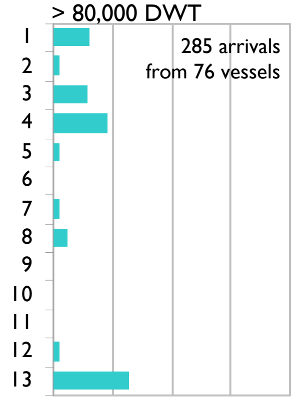
Handy
< 50,000 DWT



Panamax
50,000–80,000 DWT



Capesize
> 80,000 DWT

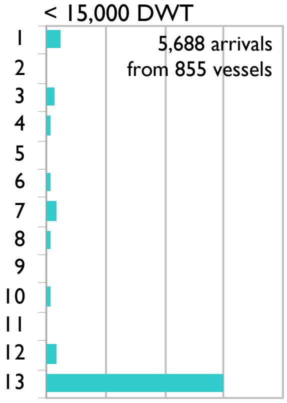


Like tankers, bulk carriers move cargo in shipload lots and carry ballast water in the absence of cargo. Bulk carriers show a similar trend, though less pronounced, than container and tank vessels. Nearly 50 percent of the arrivals for the smallest bulk carrier, Handy, come from foreign ports with transits that lie within 200 miles of shore. For the largest carriers, Capesize, the number of arrivals from foreign ports that transit only within 200 miles of shore drops to just over 30 percent, followed closely by those arrivals from the Mediterranean to the Caribbean and Gulf of Mexico (Track 4). The middle group of bulk carriers, Panamax, those between 50,000 and 80,000 DWT, is still dominated by transits within 200 miles of shore, but there are significant arrivals in transits from Northern Europe to the Caribbean and Gulf of Mexico (Track 3), the Mediterranean to the Caribbean and Gulf of Mexico (Track 4), East Asia to the West Coast (Track 5), and West Africa to East Coast, Caribbean, and Gulf of Mexico (Track 8), which demonstrate the influence of both mineral and grain shipments in the bulk trades.

General cargo vessels

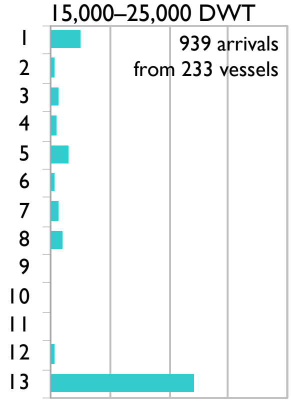
Small

< 15,000 DWT



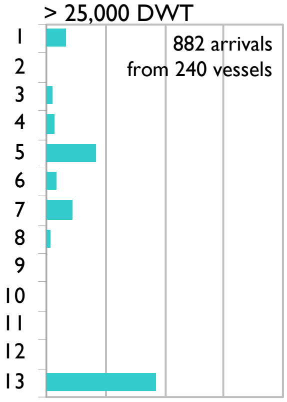
Medium

15,000–25,000 DWT



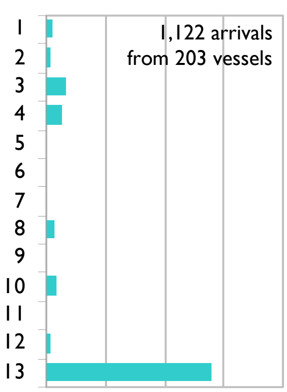
Large

> 25,000 DWT



General cargo vessels are in similar service as container ships and carry ballast water as needed to maximize trim and stability while partial cargo discharges and loadings take place at multiple ports. These vessels also show similar transit trends as container ships. Most arrivals from the small general cargo vessels come from within 200 miles of any shore. As vessels increase in size, more of them arrive from outside 200 miles of any shore, primarily East Asia to the West Coast (Track 5), Northern Europe to the East Coast (Track 1), and South America to the East Coast (Track 7).

Gas carriers

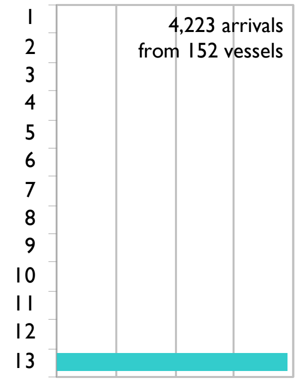


Gas carriers operate as tankers and bulkers, with cargo moved in shipload lots. The LNG and LPG carriers that transit outside 200 miles of any shore arrive primarily from Northern Europe and the Mediterranean to the Caribbean and Gulf of Mexico (Tracks 3 and 4).

Tracks

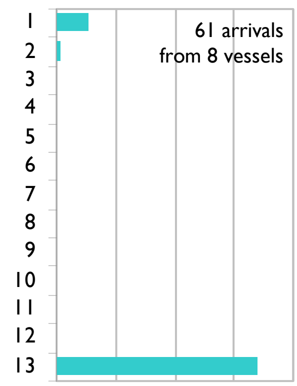
- Northern Europe to the East Coast
- Mediterranean to the East Coast
- Northern Europe to the Caribbean and Gulf of Mexico
- Mediterranean to the Caribbean and Gulf of Mexico
- East Asia to the West Coast
- Southeast Asia to the West Coast
- South America to the East Coast
- West Africa to the East Coast, Caribbean, Gulf of Mexico
- Central America to the Pacific Islands
- East Asia to Alaska
- West Africa to the West Coast and Hawaii
- Southeast and East Asia to the Pacific Islands
- Transit within 200 miles of any shore

Passenger ships



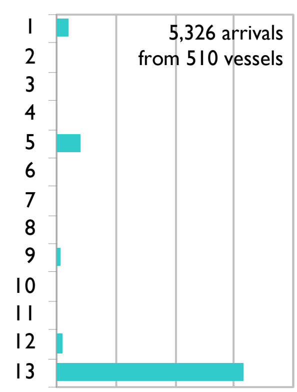
Passenger ships carry relatively little ballast water, as they load and unload only small quantities of cargo, and ballast water operations are conducted primarily for passenger comfort during voyages. Almost all arrivals for passenger ships come from within 200 miles of any shore, with concentrations of arrivals from the Caribbean, Mexico, and Alaska.

Combination vessels



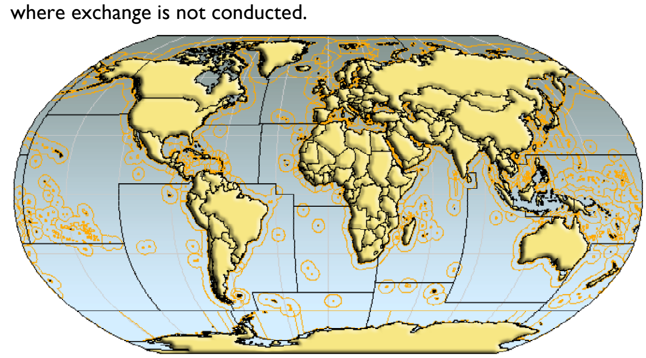
There are relatively few arrivals from combination vessels into US ports. Those that arrive from outside 200 miles of any shore come mainly from Northern Europe to the East Coast (Track 1).

ROROs



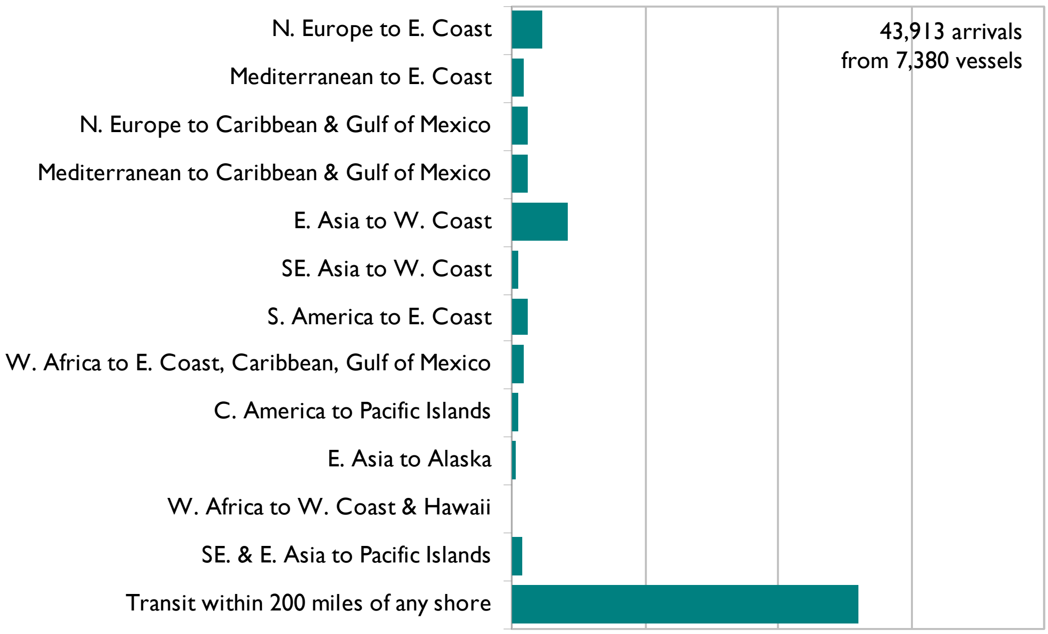
ROROs ballast water as needed to maximize trim and stability while partial cargo discharges and loadings take place at multiple ports. These vessels consist primarily of vehicle carriers with some car ferries as well. The influence of the Asian and European auto markets can be seen in the arrivals from Northern Europe to the East Coast (Track 1) and East Asia to the West Coast (Track 5).

EEZs (orange boundaries) extend from shore out to 200 miles. In general, vessels should not conduct ballast water exchanges in EEZs. Much of the Caribbean and South Pacific are a series of overlapping EEZs where exchange is not conducted.



Source: SEA AROUND US PROJECT, http://www.seaaroundus.org/eez/eez.aspx

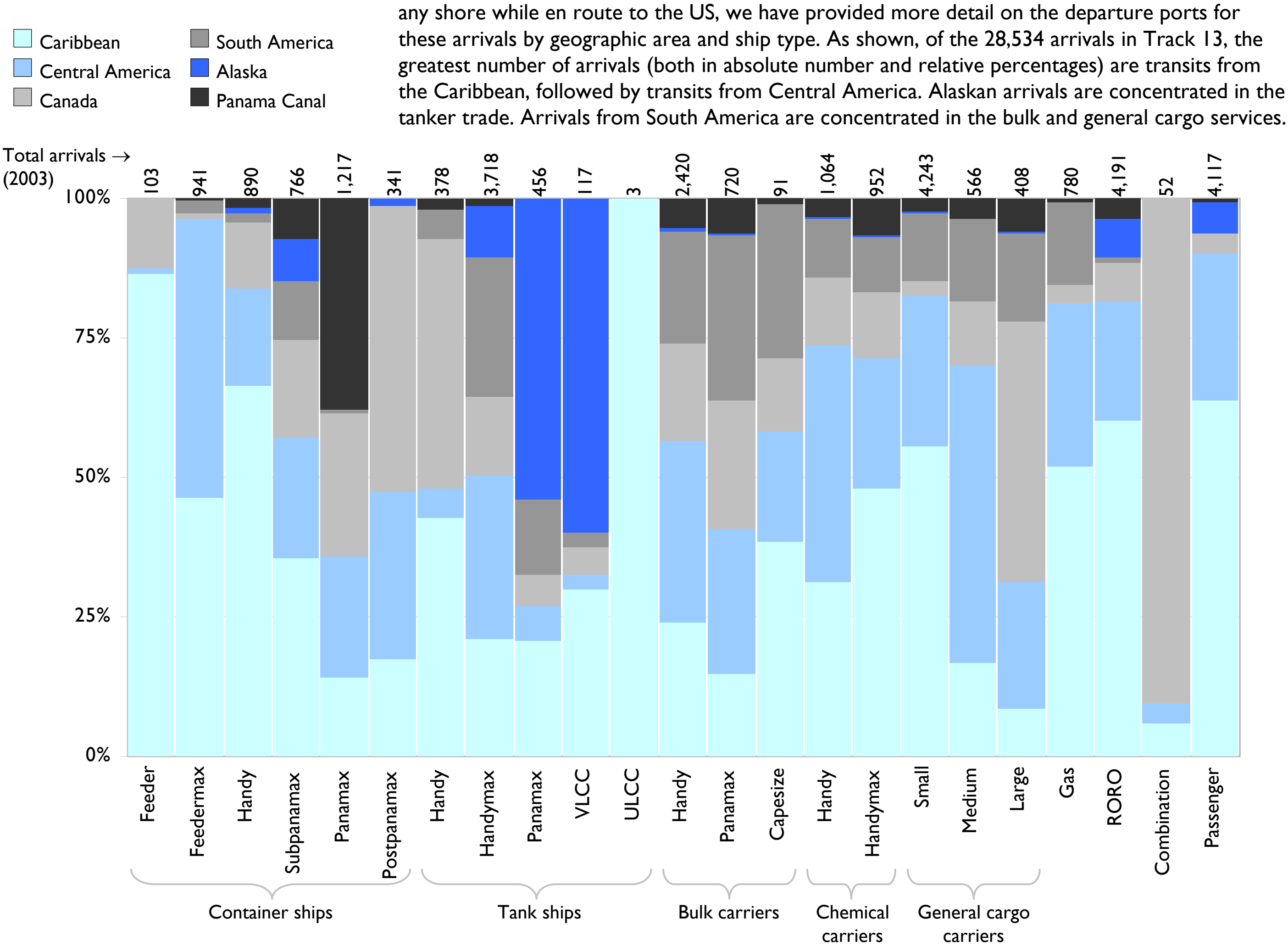
All vessels



The overall majority of arrivals (65 percent) are from ports located such that these vessels do not travel more than 200 miles from any shore while en route to the United States. Vessels transiting from within 200 miles of any shore do not have the opportunity to conduct a mid-ocean ballast water exchange. As a result, the ballast water discharged from these vessels into US waters may contain non-indigenous species that could successfully be introduced and could subsequently become invasive. If these same vessels were to conduct an exchange in coastal areas, the risk of invasive species introduction would remain.

Detail of transits within 200 miles of any shore (Track 13)

Because such a large majority of arrivals are from vessels that do not transit outside 200 miles of any shore while en route to the US, we have provided more detail on the departure ports for these arrivals by geographic area and ship type. As shown, of the 28,534 arrivals in Track 13, the greatest number of arrivals (both in absolute number and relative percentages) are transits from the Caribbean, followed by transits from Central America. Alaskan arrivals are concentrated in the tanker trade. Arrivals from South America are concentrated in the bulk and general cargo services.



The cost assessment

Acronyms

DWT	Dead Weight Tons
EEZ	Exclusive Economic Zone
LNG	Liquid Natural Gas
LPG	Liquid Petroleum Gas
NBIC	National Ballastwater Information Clearinghouse
RORO	Roll-on/Roll-off vessel
TEU	Twenty-foot Equivalent Unit
ULCC	Ultra Large Crude Carrier
VLCC	Very Large Crude Carrier

Assumptions

For this analysis, we collected all commercial vessel visits for 2003 from the Coast Guard's National Vessel Movement Center to develop a picture of transit patterns for ships making port calls to the US. We assigned the last port of call to a port zone to group the ports geographically. US ports were similarly grouped into coastal zones (East Coast, Gulf Coast, West Coast, etc.).

We identified 13 transit tracks that accounted for most of the routes that vessels transit. The transit track information allowed us to apply the probability of weather conducive to conduct a ballast water exchange to the cost calculation. Wave height statistics were used to determine the probability that weather conditions would permit ballast water exchange in the sea areas applicable to each vessel track. All possible transits are not captured by the 13 transit tracks listed. These transit tracks were assumed, however, to be the most likely routes for shipping.

Where two tracks could have been assigned, we selected the transit track with the lower probability of wave heights acceptable for exchange. For example, if a vessel departs from Calcutta, India, bound for New York, it is equally likely that it would transit east through the Indian and Pacific Oceans versus west through the Mediterranean Sea and Atlantic Ocean. In this case, we assigned this arrival to the Mediterranean to the East Coast (Track 2) because this transit track is less likely to have sea states conducive to ballast exchange than either of the tracks through Asia. We grouped routes in which vessels would typically not travel more than 200 miles from any shore into one transit track—Transit within 200 miles of any shore (Track 13). The probability of exchange within that track was 0 because vessels transiting this track do not have the opportunity to conduct mid-ocean ballast exchange. Arrivals into the Great Lakes were not included in this analysis.

Determining the amount of ballast water typical for each vessel type presented several challenges. Ballast water management data for arriving vessels have been collected through the NBIC (National Ballastwater Information Clearinghouse). We used the average of reported ballast water capacities revealed in the NBIC data for each vessel type. The capacities are consistent with data from *Lloyd's Register* and published literature.

For a flow-through exchange, three volumes of ballast tank capacity are pumped, while two volumes of the ballast tank capacity are pumped for sequential (empty/refill) exchange. We assumed that bulkers, tankers, and gas carriers complete flow-through exchanges, and all other vessel types complete sequential exchange.

To determine pumping costs, we calculated a uniform cost for pumping one cubic meter of ballast water. The cost calculated was based on pump capacities ranging from 220 m^3/hr to 2,280 m^3/hr. We used an estimate of \$0.013/m^3 pumped to reflect that most vessels transiting US waters are in the mid-sized range.

Another important component in the cost of ballast water exchange was the additional maintenance cost accrued because the ballast pumps are required to pump the ship's capacity in ballast water for every trip into the US EEZ when cargo operations are planned. In order to adequately account for the extra maintenance burden, a uniform annual maintenance cost of 10 percent of the capital cost of a ballast pump system was added for each vessel conducting exchanges, whether a vessel made a single US port call per year or 20 visits to US waters. This maintenance cost was assumed to cover replacement parts for pumps and to include impellers and maintenance of piping system components such as valves.

Cost calculations for ballast water exchange

Using large bulk carriers as an example, we discuss the cost calculation. The cost for all the bulk carriers greater than 80,000 DWT (Capesize), transiting from Northern Europe to the East Coast (Track 1), based on 2003 arrival data would be as follows.

Of the 285 foreign arrivals in 2003 for Capesize bulk carriers, 42 arrivals were from Northern Europe to the East Coast. These vessels were subject to sea states where wave heights were 3 meters or less about 57 percent of the time and thus would be considered able to do an exchange 57 percent of the time. Capesize bulk carriers were found to have an average ballast capacity of 63,000 m^3, and this capacity would be pumped by the vessel's ballast system three times to accomplish a flow-through exchange. With the \$0.013/m^3 cost of moving ballast water, the Capesize vessels on this transit track would have a total annual cost of approximately \$60,000—

42 arrivals $\times$ 57% probability of favorable sea state $\times$ 63,000 m^3 ballast per arrival $\times$ 3 volumes of total ballast capacity pumped $\times$ \$0.013/m^3 ballast pumped $\approx$ \$58,820

Added to the costs for all other transit tracks, the total cost of exchanges for Capesize bulkers is \$323,448.

We then calculated the cost of maintenance for the ballast pumps. We determined how many of the Capesize vessels in this category transited within 200 miles of shore exclusively. We subtracted these vessels from our population, since we determined they would seldom, if ever, conduct an exchange before entering US waters. For the remaining vessels that transit at least once outside 200 miles of shore (69 vessels), we assigned a maintenance cost for these vessels. We assumed that maintenance would be 10 percent of the capital cost of the pumping system, or \$3,500 annually. For the entire Capesize bulker category, the annual maintenance cost was an estimated \$241,500. When added to the \$323,448 cost of conducting exchanges, this yielded a total cost of exchange operations for Capesize bulkers of roughly \$564,948 annually.

Summary of estimated costs for ballast water exchange

The table below presents the estimated total cost of exchange for each of the 23 vessel types along with summary information for the analysis. As shown, the weighted probability a vessel performs exchange (third column) is unique for each vessel type. For Handy bulk carriers, approximately 52 percent of the vessel arrivals were from within 200 miles of shore, with no possibility of exchange. The remaining 48 percent of the vessels then transited through sea areas where wave heights further reduce the possibility of exchange to 32 percent overall for Handy bulk carriers. As container ships, tank vessels, bulk carriers, and general cargo vessels increase in cargo capacity and have fewer transits within 200 miles of shore, there is an increase in the probability these vessels will be able to conduct an exchange because of the tracks these vessels most often transit. The probability for exchange for tankers, for example, increases from a weighted probability of 15 percent for Handymax tank ships to 66 percent for ULCCs. The predominant ocean crossings and ability to handle more severe weather conditions is reflected in the high overall probability for an exchange in the largest container vessels, Postpanamax, with a weighted probability of 74 percent.

We estimate the total annual cost of ballast water exchange for entry into US waters will be approximately $22.5 million. It is important to note that the assumptions we made regarding exchange likely overestimate annual cost. For example, we assumed that all ballast will be exchanged on every voyage to a US port from outside the US EEZ. Most operators will likely exchange only the tanks they need to before entering port, depending on the cargo operations they intend to perform once in the United States. Also, we assigned a uniform annual maintenance cost to every vessel that made at least one transit outside the US EEZ; for many vessels that make only one port call in the United States from outside the EEZ, this would overstate the annual cost to this vessel. We believe, however, that even though we could be overestimating the annual cost of ballast water exchange, our costs certainly represent the magnitude of expenditures we would expect to see.

Summary of cost (2003 arrival data)

Vessel type	Vessels	Weighted probability that vessel performs exchange	Annual exchanges	Estimated cost per exchange	Annual maintenance cost per vessel conducting exchange	Total annual exchange cost ($ Millions)	Total annual maintenance cost ($ Millions)	Total annual cost ($ Millions)
Container ships								
Feeder	8	15%	18	$75	$1,500	$0.001	$0.006	$0.007
Feedermax	45	13%	144	96	1,500	0.014	0.021	0.035
Handy	220	45%	744	208	1,500	0.155	0.225	0.380
Subpanamax	263	55%	978	361	2,000	0.354	0.362	0.716
Panamax	345	51%	1,325	447	2,000	0.592	0.484	1.076
Postpanamax	202	74%	1,090	497	2,000	0.541	0.388	0.929
Tank ships								
Handy	111	25%	144	250	2,500	0.036	0.203	0.238
Handymax	578	15%	738	1,229	3,000	0.907	1.314	2.221
Panamax	163	38%	358	2,110	3,500	0.756	0.501	1.256
VLCC	199	58%	333	3,479	5,500	1.159	1.045	2.204
ULCC	20	66%	30	3,627	6,000	0.111	0.120	0.231
Bulk carriers								
Handy	1,519	32%	1,483	690	2,500	1.024	2.975	3.999
Panamax	852	43%	848	1,388	3,000	1.177	2.181	3.358
Capesize	76	46%	132	2,457	3,500	0.323	0.242	0.565
Chemical carriers								
Handy	280	28%	413	166	2,500	0.069	0.518	0.586
Handymax	298	37%	573	242	2,500	0.139	0.610	0.749
General cargo vessels								
Small	855	25%	1,396	96	1,500	0.134	0.854	0.988
Medium	233	38%	356	208	1,500	0.074	0.225	0.299
Large	240	52%	457	361	2,000	0.165	0.392	0.557
Other vessels								
Gas carrier	203	21%	236	452	3,000	0.107	0.414	0.521
RORO	510	14%	731	200	2,500	0.146	0.888	1.034
Combination vessel	8	14%	8	190	2,000	0.002	0.008	0.010
Passenger ship	152	2%	104	68	1,500	0.007	0.077	0.084
Total	**7,380**		**12,638**			**$7.991**	**$14.050**	**$22.041**